

## CURRICULUM VITAE

**Richard J. Gilbert**

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### EDUCATION

B.S., CORNELL UNIVERSITY, Electrical Engineering (with honors), 1966

M.S., CORNELL UNIVERSITY, Electrical Engineering, 1967

M.A., STANFORD UNIVERSITY, Economics, 1975

Ph.D., STANFORD UNIVERSITY, Engineering-Economic Systems, 1976

### PRESENT POSITIONS

UNIVERSITY OF CALIFORNIA, BERKELEY, 2002- present  
Chair, Department of Economics

UNIVERSITY OF CALIFORNIA, BERKELEY, 1983- present  
Professor of Economics

UNIVERSITY OF CALIFORNIA, BERKELEY, 1997-present  
Affiliated Professor of Business Administration

### PROFESSIONAL EXPERIENCE

U.S. DEPARTMENT OF JUSTICE, Antitrust Division, 1993-1995  
Deputy Assistant Attorney General for Economics

UNIVERSITY OF CALIFORNIA, BERKELEY, 1990-1993  
Affiliated Professor of Business Administration

UNIVERSITY OF CALIFORNIA ENERGY INSTITUTE, 1984-1993  
Director

STANFORD UNIVERSITY, 1982-1983

Associate Professor of Engineering-Economic Systems (with tenure)

UNIVERSITY OF CALIFORNIA, BERKELEY, 1979-1983

Associate Professor of Economics (with tenure)

UNIVERSITY OF CALIFORNIA, BERKELEY, 1976-1979

Assistant Professor of Economics

STANFORD UNIVERSITY, 1975-1976

Research Associate, Department of Economics and Institute for Energy Studies

U.S. NAVY, 1967-1971

Lieutenant, Senior Grade

## FELLOWSHIPS AND AWARDS

Visiting Fellow, Churchill College, University of Cambridge, 1979

Visiting Fellow, Nuffield College, University of Oxford, 1979

Fulbright Scholar, South America, 1989

Recipient of the 1<sup>st</sup> Annual Berkeley Center for Law and Technology Award for Contributions to the Development of Law and Public Policy, 1996

Listed in *Who's Who*

## PROFESSIONAL ACTIVITIES

President, *Industrial Organization Society*, 1994-1995

Associate Editor, *Journal of Sports Economics*, 1999-

Associate Editor, *Journal of Economic Theory*, 1983-1989

Associate Editor, *Journal of Industrial Economics*, 1990-1993

Associate Editor, *Review of Industrial Organization*, 1990-1993

Vice-Chair, American Bar Association Antitrust Economics Committee, 1993-1995

Co-Director, Program on Workable Energy Regulation, 1990-1993

Review Panel, National Science Foundation, Economics Program, 1985

Review Panel, National Science Foundation, Regulation Program, 1985-1986

Advisor to U.S. Department of Energy, Energy Assessment Panel on Energy Security, 1992

Member of Advisory Board, California Institute for Energy Efficiency, 1992-1993

Member of the Advisory Board, Institute for Business and Economic Research, University of California at Berkeley, 1998-present ; Chair of the Advisory Board, 2001-2.

Conference Organizer: European Summer Symposium in Economic Theory, Gerzensee, 1998; Post-Chicago Economics Conference, Washington, D.C., May 26-27, 1994; International Comparisons of Electricity Regulation, Toulouse, May 1993; Economics of Energy Conservation, Berkeley, June 1992; Telecommunications Policy Research Conference, 1988, 1989; Developments in Electricity Regulation, Berkeley, June 1987

Session Organizer: 1994 Meetings of the American Economic Association; 1987 Meetings of the Econometrics Society; 1984 Meetings of the American Economic Association; 1983 Meetings of ORSA/TIMS Associations

Nominating Committee Member, Industrial Organization Society Professional Service Award, 1998, 1999

Referee for: *American Economic Review*, *Econometrica*, *International Economic Review*, *Journal of Political Economy*, *Quarterly Journal of Economics*, *Rand Journal*, *Review of Economic Studies*. Occasional referee for other journals

Member of American Economic Association, Econometric Society, Sigma Xi, Tau Beta Pi, Eta Kappa Nu.

Associate Member, American Bar Association, Antitrust Section

## PUBLICATIONS

### Articles

- 1) "Antitrust for Patent Pools: A Century of Policy Evolution," forthcoming, *Stanford Technology Law Review*
- 2) "Allocating Transmission to Mitigate Market Power in Electricity Networks," (with Karsten Neuhoff and David Newbery), forthcoming, *Rand Journal of Economics*
- 3) "Market Structure, Organizational Structure, and R&D Diversity," (with Joseph Farrell and Michael Katz), forthcoming, *Economics for an Imperfect World: Essays in Honor of Joseph E. Stiglitz*, MIT Press.
- 4) "Is Innovation King at the Antitrust Agencies? The Intellectual Property Guidelines Five Years Later," with Willard Tom, *Antitrust Law Journal*, vol. 69, 2001, pp. 43-86.

- 5) "When Good Value Chains Go Bad: The Economics of Indirect Liability for Copyright Enforcement," with Michael Katz, *Hastings Law Journal*, vol. 52, no. 4, April 2001, pp. 961-990.
- 6) "An Economist's Guide to U.S. v. Microsoft," with Michael Katz, *Journal of Economic Perspectives*, vol. 15, no. 2, Spring 2001, pp. 25-44.
- 7) "The Analysis of Professional Sports Leagues as Joint Ventures," with Michael Flynn, *The Economic Journal*, vol. 111, no. 469, February 2001, pp. 27-46.
- 8) "Exclusive Dealing, Preferential Dealing, and Dynamic Efficiency," *Review of Industrial Organization*, vol. 16, no. 2, March 2000, pp. 167-184.
- 9) "An Economic Model of Rationing," with Paul Klemperer, *Rand Journal of Economics*, vol. 31, no. 1, Spring 2000, pp. 1-21.
- 10) "Antitrust Policy for the Licensing of Intellectual Property: An International Comparison," *International Journal of Technology Management*, vol. 19, no. 1/2, 2000, pp. 206-223.
- 11) "Competition Policy," with Oliver Williamson, *The New Palgrave Dictionary of Law and Economics*, Macmillan, 1998.
- 12) "Antitrust Issues in the Licensing of Intellectual Property: The Nine No-No's Meet the Nineties," with Carl Shapiro, *Brookings Papers: Microeconomics*, 1997, pp. 283-336.
- 13) "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?" with Severin Borenstein and A. Colin Cameron, *Quarterly Journal of Economics*, vol. 112, Issue 1, February 1997, pp. 305-339.
- 14) "An Economic Analysis of Unilateral Refusals to License Intellectual Property," with Carl Shapiro, *Proceedings of the National Academy of Sciences of the United States of America*, vol. 93, no. 23, November 12, 1996, pp. 12749-12755.
- 15) "The Use of Innovation Markets: A Reply to Hay, Rapp and Hoerner," with Steven Sunshine, *Antitrust Law Journal*, vol. 64, no.1, Fall 1995, pp. 75-82.
- 16) "Defining the Intersection of Intellectual Property and the Antitrust Laws: The 1995 Antitrust Guidelines for the Licensing of Intellectual Property," *Antitrust*, vol. 9, issue 3, Summer, 1995.
- 17) "Regulating Complementary Products: A Comparative Institutional Analysis," with Michael Riordan, *Rand Journal of Economics*, vol. 26, no. 2, Summer, 1995, pp. 243-256.
- 18) "Incorporating Dynamic Efficiency Concerns in Merger Analysis: The Use of Innovation Markets," with Steven Sunshine, *Antitrust Law Journal*, vol. 63, no. 2, Winter 1995, pp. 569-602. Reprinted in Andrew I. Gavil (ed.), *An Antitrust Anthology*, Anderson Publishing, 1996.

- 19) "The Dynamic Efficiency of Regulatory Constitutions," with David Newbery, *Rand Journal of Economics*, vol. 25, no. 4, Winter, 1994, pp. 538-554.
- 20) "A Review and Analysis of Utility Conservation Incentive Programs," with Steven Stoft, *The Yale Journal on Regulation*, Winter, 1994, pp. 1-42.
- 21) "Coordination in the Wholesale Market: Where does it Work?" with Edward Kahn and Matthew White, *The Electricity Journal*, vol. 6, no. 8, October 1993, pp. 51-59.
- 22) "Uncle Sam at the Gas Pump: The Causes and Consequences of Gasoline Distribution Regulations," with Severin Borenstein, *Regulation*, vol. 16, no. 2, 1993, pp. 63-75.
- 23) "Product Line Rivalry with Brand Differentiation," with Carmen Matutes, *The Journal of Industrial Economics*, September, 1993, pp. 223-240.
- 24) "Alternative Entry Paths: The Build or Buy Decision," with David Newbery, *Journal of Economics, Management, and Strategy*, Spring, 1992, pp. 129-150.
- 25) "Introduction to Symposium on Compatibility: Incentives and Market Structure," *The Journal of Industrial Economics*, March 1992, pp. 1-8.
- 26) "Legal and Economic Issues in the Commercialization of New Technology," *Journal of Institutional and Theoretical Economics*, March 1991, pp. 155-181.
- 27) "Multiproduct Competition," with Carmen Matutes, *Annales d'Economie et de Statistique*, vol. 18, April/June 1990, pp. 151-163.
- 28) "Optimal Patent Length and Breadth," with C. Shapiro, *Rand Journal of Economics*, vol. 21, no. 1, Spring 1990, pp. 106-112.
- 29) "The Role of Potential Competition in Industrial Organization," *Journal of Economic Perspectives*, vol. 3, No. 3, Summer 1989, pp. 107-127. Reprinted in Bonanno, G. and D. Brandolini (eds.), *Industrial Structure in the New Industrial Economics*, Clarendon Press, Oxford, 1990, pp. 38-67.
- 30) "Investment and Coordination in Oligopolistic Industries," with M. Lieberman, *Rand Journal of Economics*, vol. 18, no. 1, Spring 1987, pp. 17-33.
- 31) "Comment on Levin, R., A. Klevorick, R. Nelson, and S. Winter, 'Appropriating the Returns from Industrial Research and Development,'" *Brookings Papers on Economic Activity*, vol. 3, 1987, pp. 821-824.
- 32) "Investing Under Regulatory Uncertainty: What To Do When the Rules Change," with H. Chao and S. Peck, *Energy Systems and Policy*, vol. 9, no. 4, 1986, pp. 385-396.
- 33) "Efficient Pricing During Oil Supply Disruptions," with K. Mork, *Energy Journal*, vol. 7, no. 2, April 1986, pp. 51-68.
- 34) "Entry Deterrence and the Free Rider Problem," with X. Vives, *Review of Economic Studies*, vol. LIII(1), no. 172, January 1986, pp. 71-84.

- 35) "Competition with Lumpy Investment," with R. Harris, *Rand Journal of Economics*, vol. 15, no. 2, Summer 1984, pp. 197-212.
- 36) "Will Oil Markets Tighten Again? A Survey of Policies to Manage Possible Oil Supply Disruptions," with K. Mork, *Journal of Policy Modeling*, vol. 6, no. 1, 1984, pp. 111-142.
- 37) "Customer and Investor Evaluations of Power Technologies: Conflicts and Common Grounds," with H. Chao and S. Peck, *Public Utilities Fortnightly*, vol. 113, no. 9, April 26, 1984, pp. 36-41.
- 38) "Preemptive Patenting and the Persistence of Monopoly: Reply," with D. Newbery, *American Economic Review*, vol. 74, no. 1, March 1984, pp. 251-253.
- 39) "Uncertain Innovation and the Persistence of Monopoly: Comment," with D. Newbery, *American Economic Review*, vol. 74, no. 1, March 1984, pp. 238-242.
- 40) "Strategic Considerations in Invention and Innovation: The Case of Natural Resources," with P. Dasgupta and J. Stiglitz, *Econometrica*, vol. 51, no. 5, September 1983, pp. 1439-1448. Reprinted in Binmore, K. and P. Dasgupta (eds.), *Economic Organizations as Games*, Basil Blackwell.
- 41) "Preemption, Leapfrogging and Competition in Patent Races," with D. Fudenberg, J. Stiglitz, and J. Tirole, *European Economic Review*, vol. 22, no. 1, June 1983, pp. 3-32.
- 42) "Invention and Innovation Under Alternative Market Structures: The Case of Natural Resources," with P. Dasgupta and J. Stiglitz, *Review of Economic Studies*, vol. 49(4), no. 158, October 1982, pp. 567-582.
- 43) "Preemptive Patenting and the Persistence of Monopoly," with D. Newbery, *American Economic Review*, vol. 72, no. 2, June 1982, pp. 514-526.
- 44) "Investment Decisions with Economies of Scale and Learning," with R. Harris, *American Economic Review, Papers and Proceedings*, vol. 71, no. 2, May 1981, pp. 172-177.
- 45) "Reducing Uranium Resource Uncertainty: Is it Worth the Cost?" with R. Richels, *Resources and Energy*, vol. 3, 1981, pp. 13-37.
- 46) "Optimal Depletion of an Uncertain Stock," *Review of Economic Studies*, vol. 46, no. 142, January 1979, pp. 47-58.
- 47) "An Overview of the Economic Theory of Uncertainty and Its Implications for Energy Supply," with D. Newbery and J. Stiglitz, *Electric Power Research Institute Technical Report*, January 1978.
- 48) "Dominant Firm Pricing with Exhaustible Resources," *Bell Journal of Economics*, Autumn, vol. 9, no. 2, 1978, pp. 385-395.
- 49) "Factor Price Stabilization with Flexible Production," *Annals of Economic and Social*

*Measurement*, vol. 5, no. 5, 1978, pp. 521-533.

- 50) "The Effects of Risk on Prices and Quantities of Energy Supplies," with J. Stiglitz, *Electric Power Research Institute Technical Report*, in four volumes, May 1978.
- 51) "Potential Competition and the Monopoly Price of an Exhaustible Resource," with S. Goldman, *Proceedings of the Lawrence Symposium on Systems and Decision Sciences*, October 1977, pp. 205-207; also published in *Journal of Economic Theory*, vol. 17, no. 2, April 1978, pp. 319-331.
- 52) "Resource Extraction with Differential Information," *American Economic Review*, Papers and Proceedings, February 1977, pp. 250-254.
- 53) "LSA Operation of Large Volume Bulk Gas Samples," *IEEE Transactions on Electron Devices*, vol. Ed-14, no. 9, September 1967.

## Books

- 1) *International Comparisons of Electricity Regulation*, with Edward Kahn, Cambridge University Press, 1996.
- 2) *The Environment of Oil*, Kluwer Academic Press, 1993.
- 3) *Regulatory Choices: A Perspective on Developments in Energy Policy*, University of California Press, 1991.
- 4) *Strategic Competition and Barriers to Entry*, with P. Geroski and A. Jacquemin, in series vol. 41: Theory of the Firm and Industrial Organization, Lesourne, J. and H. Sonnenschein (eds.), *Fundamentals of Pure and Applied Economics*, Harwood Academic Press, 1990.

## Chapters in Books

- 1) "Networks, Standards, and the Use of Market Dominance: Microsoft (1995)," in Kwoka, J. and L. White (eds.), *The Antitrust Revolution: The Role of Economics*, 3<sup>rd</sup> edition, Oxford University Press, 1998.
- 2) "Unilateral Refusals to License Intellectual Property and International Competition Policy," in E. Hope and P. Maeleng (eds.), *Competition and Trade Policies: Coherence or Conflict?*, Routledge Press, London, 1998.
- 3) "The Efficiency of Market Coordination: Evidence from Wholesale Electric Power Pools," with Edward Kahn and Matthew White, in W. Sichel and D.L. Alexander (eds.), *Networks, Infrastructure, and the New Task for Regulation*, The University of Michigan Press, Ann Arbor, 1996.

- 4) "On the Delegation of Pricing Authority in Shared ATM Networks," in M. Guerin-Calvert and S. Wildman (eds.), *Electronic Services Networks: A Business and Public Policy Challenge*, Greenwood, Praeger Publishers, New York, 1991.
- 5) "Mobility Barriers and the Value of Incumbency," Chapter 8 in Schmalensee, R. and R. Willig (eds.), *Handbook of Industrial Organization*, North-Holland, 1989.
- 6) "Forecasting Technology Adoption with an Application to Telecommunications Bypass," with Jeffrey Rohlfs, in de Fontenay, A., M.H. Shugard and D.S. Sibley (eds.), *Telecommunications Demand Modelling: An Integrated View*, North-Holland, Amsterdam, 1990, pp. 399-412.
- 7) "Preemptive Competition," in G. F. Mathewson and J. Stiglitz (eds.), *New Directions in the Analysis of Market Structure*, MIT Press, Cambridge; Macmillan Press, London, 1986.
- 8) "Coping with Major Oil Disruptions," in J. Plummer, editor, *Energy Vulnerability*, Ballinger Press, 1982.
- 9) "Patents, Sleeping Patents, and Entry Deterrence," in S. Salop, editor, *Strategy, Predation, and Antitrust Analysis*, Federal Trade Commission, 1981.
- 10) "The Social and Private Value of Exploration Information," in J. Ramsey, editor, *Symposium on the Economics of Exploration for Energy Resources*, Greenwich CT: JAI Press, 1981.
- 11) "Search Strategies and Private Incentives for Resource Exploration," in R. Pindyck, (ed.), *Advances in the Economics of Energy and Resources*, vol. 2, JAI Press, 1979, pp. 149-169.
- 12) "The Economic Common Sense of Controlling Nuclear Power Development," with M. Boskin, *The California Nuclear Initiative*, Institute for Energy Studies, Stanford University, 1976; also published in *California Energy: The Economic Factors*, Federal Reserve Bank of San Francisco, 1976.
- 13) "A 1.1 GHz Scanned Acoustic Microscope," in *Acoustical Holography*, vol. 4, Plenum Press, 1972.

### Working Papers

- 1) "Vertical Integration in Gasoline Supply: An Empirical Test of Raising Rivals' Costs" (with Justine Hastings), accepted subject to minor revision, *Journal of Industrial Economics*
- 2) "Innovation and Foreclosure in a Market for Systems," (with Michael Riordan)
- 3) "Converging Doctrines? US and EU Antitrust Policy for the Licensing of Intellectual Property"

## **INVITED LECTURES AND TESTIMONY (Since 1986)**

Discussion of "Efficient Patent Pools," by Lerner and Tirole, American Economic Association Annual Meetings, January 3, 2004

"A Welfare Analysis of Intellectual Property Bundling," University of British Columbia Industrial Organization Conference, Vancouver, July 11, 2003

"A Welfare Analysis of Intellectual Property Bundling," Workshop on Licensing, Universita Cattolica del Sacro Cuore, Milan Italy, June 6, 2003

CNBC television network: discussion of gasoline pricing, August 26, 2003.

"A Taxonomy of Copyright Infringement," International Industrial Organization Conference, Boston, April 4, 2003.

"Should Good Patents Come in Small Packages? A Welfare Analysis of Intellectual Property Bundling," University of California at Berkeley Industrial Organization Seminar, February 18, 2003. Also presented at the International Industrial Organization Conference, Boston, April 4, 2003; University of British Columbia Industrial Organization Conference, Vancouver, July 11, 2003; Milan Workshop on Licensing, June 5, 2003.

Comments on a "Global Patent System for Pharmaceuticals: Avenues for Moving Forward", joint AEI and Brookings Conference, Washington, D.C., January 6, 2003.

Discussion of "Cartel Pricing Dynamics in the Presence of an Antitrust Authority," presented at the American Economic Association Meetings, Washington, D.C., January 5, 2003.

"Patent Pools: 100 Years of Law and Economic Solitude," presented at Competing Monopolies: Challenges at the Intersection of Competition and Intellectual Property Laws," University of Toronto, May 10, 2002.

"Product Improvement and Technological Tying," presented at Hong Kong University of Science and Technology, April 16, 2002 and Peking University, April 19, 2002.

"Should Innovation Have a Role in Merger Policy?," presented at the FTC/DOJ Hearings on Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy, Berkeley, CA, February 25, 2002.

"The Evolution of Guidelines," presented at the opening session of the FTC/DOJ Hearings on Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy, Washington, D.C., February 6, 2002.

"Review of OECD Proposals to Study Product Market Competition," OECD Workshop on Product Market Competition and Economic Performance, Paris, France, January 21, 2002.

"Antitrust Issues Involving Intellectual Property," Fall ABA Antitrust Forum on New Technologies/ New Administrations, Washington, D.C., November 14, 2001.

"Innovation Issues in U.S. Merger Policy," Fordham Corporate Law Institute, New York, NY, October 25, 2001.

"The Future of Energy: Policy and Use in the 21<sup>st</sup> Century," World Conference Group, University of Chicago, Chicago, October 13, 2001.

"Economics, Law, and History of Patent Pools and Cross-Licensing Arrangements," Franco-American Conference on the Economics, Law, and History of Intellectual Property Rights, University of California, Berkeley, October 6, 2001.

"Vertical Integration in Gasoline Supply: An Empirical Test of Raising Rivals' Costs" (with Justine Hastings), presented at the University of California Industrial Organization Seminar, April 10, 2001. Also presented at the conference of the International Society for New Institutional Economics, Berkeley, CA, September 15, 2001.

"Is Innovation 'King' at the Antitrust Agencies?," American Bar Association Spring Antitrust Conference, Washington, D.C., March 28, 2001.

"Is Innovation 'King' at the Antitrust Agencies?," Conference on Beyond Microsoft: Innovation and Intellectual Property, University of California at Berkeley, March 2-3, 2001.

"Mutually Assured Destruction: Implications for Ag-Bio Licensing," Conference on Intellectual Property Clearinghouse Mechanisms for Agriculture," University of California at Berkeley, February 16, 2001.

Moderator, Panel on Economic and Regulatory Issues, Conference on Regulating on the Technological Edge, University of California at Berkeley, October 19-20, 2000.

Live interview with Joe Oliver on gasoline prices, KRON Bay TV, October 9, 2000.

"Antitrust and Innovation Post-IP Guidelines, Conference on Antitrust and Intellectual Property" The Crossroads," San Francisco, June 1, 2000.

"Innovation and Foreclosure in a Market for Systems," Industrial Organization Workshop, Cornell University, Ithaca, NY, April 26, 2000.

"Competition Issues in Biotechnology," Conference on Intellectual Property and Global Biotechnology, Rockefeller Foundation, Bellagio, Italy, March 30, 2000.

"Intellectual Property and Competition Policy," National Research Council Science, Technology and Economic Policy Conference, Washington, D.C., February 2-3, 2000.

Live interview with Michael Krazny on the Microsoft case, KQED Forum, January 17, 2000.

"Technology, Antitrust, and the Presidency," The Presidency and Macroeconomic Policy

Conference, Miller Center of Public Affairs, University of Virginia, October 16, 1999.

"A Rent-Grabbing Theory of Tying," Fifth Annual Berkeley-Stanford Conference in Industrial Organization, University of California, October 9, 1999.

"Antitrust Policy in a Small Open Economy," Tel Aviv University, May 27, 1999.

"Exclusive Dealing, Preferential Dealing, and Dynamic Efficiency," Conference on Antitrust and Regulation, Tel Aviv University, May 26, 1999.

"Merger Reviews in the Telecommunications and Media Industries," Annual Spring Meeting of the ABA Section of Antitrust Law, Washington, D.C., April 14, 1999.

"Defining the Boundary Between Legitimate Cooperation and Illegal Collusion," The Conference Board 1999 Antitrust Conference, New York, N.Y., March 4, 1999.

"The Intersection of Antitrust and Intellectual Property," Conference on Antitrust Issues in High-Tech Industries, Scottsdale, AZ, February 26, 1999.

"Economic Analysis of Antitrust Rules and Intellectual Property," Conference on Antitrust in the High-Tech Industry, Menlo Park, CA, February 23, 1999.

"Evaluating the Loss of Potential Competition From ILEC Mergers," FCC Roundtable on the Economics of Mergers Between Large ILECs, Washington, D.C., February 5, 1999.

"Economic Factors in the Production, Dissemination, and Use of Scientific Databases," National Research Council Workshop on Promoting Access to Scientific and Technical Data for the Public Interest," Washington, D.C., January 14-15, 1999.

"Exclusive Dealing, Preferential Dealing, and Dynamic Efficiency," 25<sup>th</sup> Anniversary Seminar of the Economic Policy Office/Economic Analysis Group, Antitrust Division, U.S. Department of Justice, Washington, D.C., November 6, 1998.

"The Microsoft Case: Antitrust for the 21<sup>st</sup> Century?" San Diego Business Round Table, San Diego, CA, October 23, 1998.

"Exclusive Dealing and Antitrust Policy," Department of Economics, University of California at San Diego, San Diego, CA, October 22, 1998.

"Antitrust Policy for the Computer Industry," Microprocessor Forum, San Jose, CA, October 14, 1998.

"Incorporating Economic Principles in Intellectual Property Damages," conference on The Economic Analysis of Intellectual Property Damages, San Francisco, CA, October 2, 1998.

"Antitrust Issues in the Licensing of Intellectual Property," (paper presentation and roundtable discussion leader), European Summer Symposium in Economic Theory, Gerzensee, Switzerland, June 29-July 4, 1998.

"Antitrust Issues in the Licensing of Intellectual Property: Microsoft Meets Contract

Theory," (paper presentation and roundtable discussion leader), Conference on Regulation and Competition in Network Industries, June 5-6, 1998, Barcelona, Spain.

Discussant of Licensing in the Chemical Industry, Conference on Intellectual Property, Stanford University, April 17-18, 1998.

"Antitrust in High Technology Markets," speech before the Peninsula Intellectual Property Law Association, Palo Alto, CA, March 24, 1998.

Session Moderator on the Current Regulatory Environment, Conference on Telecommunications Incentives to Invest in Advanced Infrastructure, University of California at Berkeley, March 20, 1998.

"Identifying Limits on Relations Among Rivals," presented at the Conference Board 1998 Antitrust Conference, New York, NY, March 5, 1998.

"The DOJ/FTC Antitrust Guidelines for the Licensing of Intellectual Property," invited lecture, Boalt School of Law, University of California at Berkeley, February 4, 1998.

"Antitrust in High Technology Markets," speech before the Intellectual Property Institute, San Francisco, CA, January 26, 1998.

"Comments on the Antitrust Treatment of Joint Ventures," invited participant in Federal Trade Commission Roundtable on per se illegality and rule of reason analysis of joint ventures, Washington D.C., December 12, 1997.

"Standards for Evaluating Market Power in Electricity," California ISO Market Power and Monitoring Workshop, Oakland, CA, November 18, 1997.

"Antitrust Issues in the Licensing of Intellectual Property," invited lecture, Boalt School of Law, University of California at Berkeley, November 13, 1997.

"Antitrust Issues and the Licensing of Intellectual Property," Third Annual Berkeley-Stanford Conference in Industrial Organization, Berkeley, CA, October 18, 1997.

"The Microsoft Antitrust Wars," invited lecture, Public Policy School, University of California at Berkeley, October 14, 1997.

"Electricity Merger Analysis: Does the FERC Follow the Merger Guidelines?" IAEE Annual Conference, San Francisco, CA, September 8, 1997.

"Networks and Bottlenecks," conference on Bridging Digital Technologies and Regulatory Paradigms, University of California at Berkeley, June 27, 1997.

"Unilateral Effects Analysis: Vertical Competition Issues in Telecommunications," conference on Competition Policy in Communications Industries: New Antitrust Approaches, Washington, D.C., March 10-11, 1997.

"Can Electricity Markets Be Competitive?" conference on Market Power and Competition in Electricity, Washington, D.C., February 27-28, 1997.

"An Economic Analysis of Unilateral Refusals to License Intellectual Property," New York University School of Law, February 6, 1997.

"Competition Policy in the High-Tech, Global Marketplace," Meeting of the American Economics Association, New Orleans, January 5, 1997.

"The Role of the State Public Utilities Regulatory Commission in Competition Policy," remarks before the Staff Subcommittee for NARUC on Strategic Issues, San Francisco, November 18, 1996.

"Economic Issues Copyright Protection: the Lotus v. Borland Case," National Bureau of Economic Research Summer Institute, Cambridge, MA, July 23, 1996.

"Unilateral Refusals to License Intellectual Property and International Competition Policy," conference on "Competition Policies for an Integrated World Economy," Oslo, Norway, June 14, 1996.

"Applying the Merger Guidelines to Electricity Mergers," Conference of Public Utility Counsel, San Francisco, CA, May 17, 1996.

"The US DOJ/FTC Intellectual Property Guidelines," invited address at the conference on "Competition Policy, Intellectual Property Rights, and International Economic Integration," Ottawa, Canada, May 12, 1996.

"Competition Issues Related to Software Patents," Berkeley Roundtable on Software Innovation, Berkeley, CA, April 26, 1996.

Moderator, "Panel on *Image Technical Services v. Eastman Kodak*," San Francisco Bar Association, San Francisco, CA, April 26, 1996.

"Economic Perspectives on Compulsory Licensing of Intellectual Property," American Bar Association Spring Antitrust Meeting, March 27, 1996, Washington, D.C.

Panel Discussant, "The 1995 Guidelines for the Licensing of Intellectual Property," High Technology Section of the Santa Clara Bar Association, Santa Clara, CA, February 7, 1996.

"Microeconomic Analysis in Government Policy," American Economic Association Annual Meeting, San Francisco, CA, January 5, 1996.

"Analysis of Market Power in the Computer Industry," Chinese Government Official Training Program, Biltmore Hotel, Santa Clara, CA, December 8, 1995.

"Antitrust Evaluation of Electric Utility Mergers," The Third DOE-NARUC National Electricity Forum, Washington, D.C., December 5, 1995.

"Responding to Structural Change: A Call for a Review of the Competitive Consequences of Hospital Mergers," en banc testimony before the Federal Trade Commission Hearings on Global and Innovation-Based Competition, Washington, D.C., November 14, 1995.

"Economic Perspectives on Compulsory Licensing of Intellectual Property," presented at the 3rd Annual Golden State Antitrust and Trade Regulation Institute, San Francisco, CA, October 27, 1995.

"Comments on the Use and Misuse of Innovation Market Analysis," en banc testimony before the Federal Trade Commission Hearings on Global and Innovation-Based Competition, Washington, D.C., October 25, 1995.

"An Economic Analysis of Unilateral Refusals to License Intellectual Property," presented at the National Academy of Sciences Colloquium on Science, Technology and the Economy, Irvine, CA, October 20-22, 1995.

"Discussion of 'Restructuring and Regulatory Reform in Network Industries; from Hierarchies to Markets'," by Paul Joskow, presented at the conference on Firms, Markets and Hierarchies, Berkeley, CA, October 6-8, 1995.

"Compulsory Licensing: Practical Facts and Economic Musings," American Bar Association Section of Antitrust Law, Annual Meeting, Chicago, IL, August 8, 1995. Also presented at Intellectual Property Antitrust 1995, Practising Law Institute, San Francisco, CA, July 20, 1995.

"Joint Venture Access Rules: An Antitrust Evaluation," American Bar Association Section of Antitrust Law, Annual Meeting, Chicago, IL, August 7, 1995.

"Competition in Electric Power Generation: Market Power and Market Pricing," Harvard Electricity Policy Group, Cambridge, MA, April 18, 1995.

"The 1995 Antitrust Guidelines for the Licensing of Intellectual Property: New Signposts for the Intersection of Intellectual Property and the Antitrust Laws," American Bar Association Section of Antitrust Law Spring Meeting, Washington, D.C., April 4, 1995. Also presented at The Aerospace Industries Association, Washington, D.C., April 20, 1995; The Fordham International Antitrust Conference, New York, NY, April 21, 1995.

"The Antitrust Agenda in the Clinton Administration," American Bar Association Business Law Section, March 24, 1995.

"The New Federal Antitrust Licensing Guidelines: The Music Behind the Words," Price Waterhouse Intellectual Property Conference, Tucson, AZ, February 23, 1995.

"Intellectual Property and the Antitrust Laws: Protecting Innovators and Innovation," Annual Winter Meeting of the Licensing Executives Society, Phoenix, AZ, February 17, 1995. Also presented at The Conference Board, New York, NY, March 2, 1995; The Antitrust '95 Conference, Washington, D.C., March 15, 1995.

"Traditional Antitrust for Non-Traditional Markets: The Case of High-Tech and Intellectual Property," American Bar Association Conference, Washington, D.C., November 17, 1994.

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"The Nuclear Industry After Chernobyl," University Explorer Series #860630, June 30, 1986.

## **BACKGROUND**

Born January 14, 1945

Married (Sandra), two children (Alison, David)

U.S. citizen

March 2004



## **DECLARATION OF WILLIAM HOGG AND MARK AUSTIN**

### **I. BIOGRAPHICAL INFORMATION**

1. William Hogg is the Vice President, Network Strategic Planning, of Cingular Wireless LLC ("Cingular"), and is responsible for planning activities concerning radio, core network, and standards. In that position he is responsible, among other things, for network and technology strategic planning in the areas of core network switching and 2G and 3G radio access. He received his M.S.E.E. from the Georgia Institute of Technology and his M.B.A. from the University of South Florida. From 2001 to 2003 he was Cingular's Vice President-Network Transformation, in which position he was responsible for overseeing Cingular's conversion from TDMA to GSM technology. Previously, he has been the Chief Technology Officer for Cingular Interactive and held various technical management and planning positions with Verizon Wireless, GTE Wireless, and GTE Airfone. He is the holder of six U.S. patents.

2. Mark Austin is a radio technology and communications manager with over 17 years of experience, 14 of which relate to RF engineering and planning of wireless systems, and is highly experienced with respect to both planning and operations involving TDMA and GSM deployment. He received his Ph.D. with Sigma Xi's thesis award from the Georgia Institute of Technology in 1994. From 1986 to 1988 he co-developed and deployed the first transmission system for HDTV over fiber while at Bellcore. From 1989 to 1991 he developed a software defined radio for radar systems while at Georgia Tech Research Institute. From 1994 to 2001 at BellSouth Cellular Corp. he managed the headquarters advanced technology team, had substantial responsibility for the company's technical planning for TDMA and GSM, and also was a contributor to the TDMA and GSM/EDGE standards evolution as chair of the signal processing working group in the TIA standards committee. From 2001 to 2003 he was Director of Radio Planning Technology at Cingular, a position in which he was responsible for the radio planning strategy and implementation for Cingular's GSM/EDGE overlay. Since 2003 he has been the Director of Operations for Puerto Rico/US Virgin Islands for Cingular Wireless. He has published over 20 reviewed papers, has 5 patents granted, and recently served as the technical program chair for the 2003 Wireless and Personal and Mobile Communications (WPMC) Conference.

### **II. INTRODUCTION**

3. The merger of Cingular and AT&T Wireless Services, Inc. ("AWS") under a single parent, Cingular Wireless Corporation, will provide the combined company with the coverage and spectrum necessary for making significant improvements in the quality of service each company currently provides its existing customers while simultaneously making it possible to offer advanced broadband services sooner and in more places. It will also enlarge the area where the two companies' customers can receive full-featured service, providing a more complete on-network service area needed to compete in today's national wireless market.

4. As discussed in the Declaration of Marc Lefar ("Lefar Declaration"), quality of service, scope of coverage, and, increasingly, the ability to offer advanced services are key elements of competition among wireless carriers. Quality of service and scope of coverage are the leading factors causing wireless customers to change carriers. This merger is designed to address the service quality and coverage issues faced by both companies, as well as speed the availability of advanced services.

5. Both Cingular and AWS have legacy analog and TDMA digital customers whose needs have to be accommodated for years to come. This obligation limits the amount of spectrum that either company can devote to the more efficient GSM digital technology or to the evolution from GSM to more advanced broadband services, and it takes a toll on the quality of service they can offer. As a result, both companies face a competitive disadvantage, because none of the other national wireless carriers needs to support customers relying on two legacy technologies in addition to a digital technology which offers a viable path toward the new services customers want.

6. The merger offers several important technical efficiencies that flow from the combination of these two companies' networks and furthers the interests of wireless consumers:

- ***Improved Service Quality.*** By combining the two companies' networks and spectrum, the merged company will be able to address service quality issues that are aggravated by the need to support multiple legacy technologies, reducing blocked and dropped calls, improving voice quality, and better accommodating customer growth in the voice and data services currently offered.
- ***Faster, More Extensive Deployment of Advanced Services.*** Integrating the two companies' multiple networks and spectrum holdings to serve a unified customer base will provide the necessary spectrum "headroom" for rolling out the advanced services consumers increasingly demand, more quickly and in more areas than either company could achieve on its own, and permitting advanced services to be delivered in rural as well as urban areas.
- ***Better National Coverage.*** Combining the companies' networks will also provide customers of the merged company with a more extensive nationwide service area, especially in rural areas, than either company can offer on its own.

### III. TECHNOLOGICAL OVERVIEW

7. Wireless service has been under constant redevelopment since cellular service was introduced in the early 1980s, in response to continued growth in subscribership and usage patterns, both in the United States and throughout the world. As the number of users has grown, so have their expectations for service quality, coverage, and access to new features and functionalities. Wireless vendors and service providers have responded to customers' demands by producing new generations of handsets and infrastructure, and each new generation of wireless equipment and service has resulted in increasing competition among providers to offer the new features and services to customers, while continuing to serve the needs of their existing customers. This merger provides Cingular with the ability to provide broadband third generation wireless service, featuring ubiquitous high-speed digital connections that will enable customers to access broadband video, music, information, and entertainment, while still supporting customers' continuing need for first-generation analog voice services and second-generation digital voice and data services.

8. **Analog Cellular Service.** The first generation of high-capacity wireless service in the United States came into being in the early 1980s with the establishment of analog 850 MHz cellular networks. The FCC required cellular system operators to provide analog service, following the Advanced Mobile Phone Service (“AMPS”) standard. All 850 MHz cellular licensees are required by the FCC to offer analog service available throughout their coverage areas until February 2008, when the analog requirement is scheduled to sunset. Analog cellular service is less efficient in how it uses spectrum and more susceptible to interference than the digital technologies that followed it. Analog cellular service was designed for voice transmission but can also be used, with a modem, for low-speed data connections.

9. **Second-Generation Digital Cellular Service.** Several digital technologies were subsequently developed for the second generation (“2G”) of wireless services. Carriers in the United States initially relied on two digital technologies: Time Division Multiple Access (“TDMA”) and Code Division Multiple Access (“CDMA”). TDMA fits three voice channels into a paired 30 kHz channel and thereby provides a 3× increase in capacity over analog. CDMA uses a more complex scheme, spreading multiple voice channels across a paired 1.25 MHz channel, yielding about a 6× advantage over analog.

10. A different 2G standard, Global System for Mobile Communications (“GSM”) was developed in Europe, where it was deployed in the early 1990s. It grew rapidly there and was subsequently deployed in numerous other parts of the world, becoming a worldwide standard. GSM places multiple voice channels into separate time slots in a paired 200 kHz channel and employs frequency-hopping; its capacity is about 4-6× that of analog service, but can be increased to 10× that of analog by employing adaptive multirate (“AMR”) voice coders. To reach this maximum level of efficiency, GSM requires 20 MHz of spectrum; with less than 20 MHz, a GSM network uses a higher proportion of its spectrum for control channels that reduce its overall efficiency.

11. In the United States, 2G service was not deployed until the mid-1990s, when digital service was both incorporated into existing 850 MHz cellular networks and employed as the basis for the all-digital 1900 MHz personal communications service (“PCS”) networks that were licensed starting in 1995. TDMA technology was the first 2G technology available for deployment in the 850 MHz band; GSM was not available for the U.S 850 MHz cellular frequency band until 2002, and CDMA’s availability lagged behind TDMA by several years. All three technologies were available for use in the 1900 MHz band soon after licenses were awarded.

12. When the predecessors of Cingular and AWS had to choose a 2G technology for their 850 MHz networks, their choices were limited. GSM was not then available at 850 MHz. CDMA was largely unproven, and it was unclear when it would become viable. As a result, the predecessors of Cingular and AWS were required to roll out TDMA technology in markets with a large number of minutes or see service quality decline precipitously. The introduction of digital technology had other advantages — digital phones were smaller and lighter than analog handsets, with longer battery life due to reduced power consumption, and offered text messaging capabilities.

13. Given the advantages of TDMA over analog, and driven largely by capacity constraints, the predecessors of Cingular and AWS were among the first to deploy digital service at 850 MHz. By choosing TDMA, they were not only able to improve their service quality and ca-

capacity but were also able to claim a marketing advantage by deploying digital service before CDMA digital equipment was widely available.

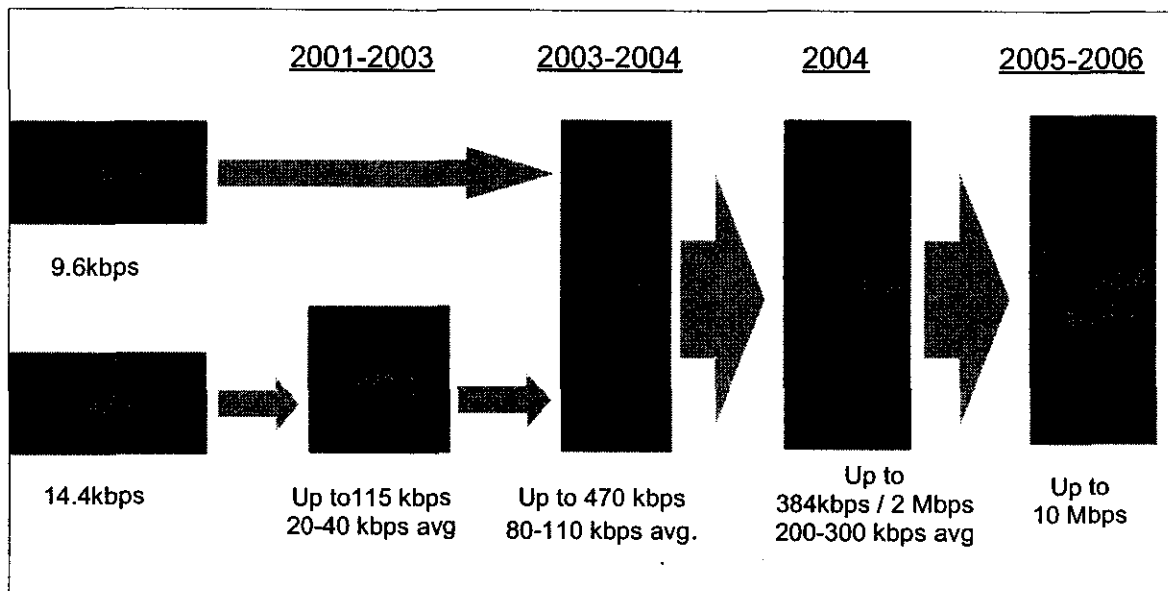
14. After the 1900 MHz PCS licenses were awarded, the companies constructing these networks could choose between GSM, CDMA, and TDMA. Vendors had adapted GSM to the 1900 MHz band, so GSM was readily available as a basis for 1900 MHz networks, unlike 850 MHz. As a result, the earliest PCS systems on the air used GSM technology, and one of Cingular's predecessors constructed an early 1900 MHz GSM network in California and Nevada. T-Mobile and its predecessor companies used GSM exclusively for PCS deployment. Other nationwide operators used CDMA to construct PCS systems — Sprint and Verizon Wireless have built exclusively CDMA networks at 1900 MHz.<sup>1</sup> Cingular and AWS, and their predecessors, used combinations of TDMA and GSM technologies in building their 1900 MHz networks.

15. ***Third-Generation and "2.5G" Digital Technologies.*** During the late 1980s and the 1990s, a variety of third-generation ("3G") technologies were under development, with the objective of meeting consumers' demand for a wide variety of new, innovative services requiring increasingly higher bandwidth. Appendix 1 illustrates the data speed requirements for a variety of these types of services. As shown in that Appendix, services such as interactive text messaging require only relatively low speed data communications (up to 10 kbps), which can be provided by any of the 2G technologies. Elementary (non-graphics-intensive) web browsing, simple game downloads, and email typically require somewhat higher speeds (10-35 kbps), and are only marginally acceptable when using 2G technologies. 2.5G service provides the increased bandwidth (35-70 kbps) needed for more data-intensive applications, such as mobile-to-mobile photo messaging, sending and receiving email with complex attachments, such as word-processing documents and spreadsheets, synchronizing a personal digital assistant with one's desktop computer, and interacting with corporate web-based applications. The next step up is to applications and services such as video and audio streaming, downloading songs, and using a laptop computer for remote access to a home or office desktop through a virtual private network, which will typically require early 3G technology's speeds, (70-200 kbps). In the near future, consumers will demand broadband 3G services with sufficient bandwidth (200 kbps to 22 Mbps) to be able to download entire albums and movies, participate in videoconferences, engage in real-time multiplayer games, and transfer high-resolution pictures and graphics. High-bandwidth services such as these are currently available in Japan and South Korea, where they are in high demand, and are increasingly popular in Europe as they become available.

16. For GSM and TDMA, the path for evolution toward 3G is illustrated in Figure 1:

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<sup>1</sup> The only exception is Sprint's first PCS system, which was built as an experimental system before the PCS rules were adopted, when CDMA was not yet ready for deployment. That system initially used GSM.



**Figure 1. GSM and TDMA 3G Evolution**

17. As illustrated above, the General Packet Radio Service (“GPRS”) standard is an intermediate “2.5G” technology providing low- to medium-speed data transmission capability. Enhanced Datarate for Global Evolution (“EDGE”) is an initial stage of 3G technology providing medium-speed data transmission capability. These technologies use the same channelization as standard GSM, so they can be integrated with existing GSM networks.

18. The broadband 3G standard for GSM, variously known as Wideband CDMA (“W-CDMA”) and Universal Mobile Telephone System (“UMTS”), provides high-speed data transmission. Since GSM/GPRS/EDGE uses a different radio access technology and wideband channelization, it requires clear spectrum and cannot be integrated into existing GSM radio networks. UMTS can provide varying rates of data transmission, initially ranging from 384 kbps to 2 Mbps depending on the users’ distance from the base station, and can be upgraded to 10 Mbps by implementing High Speed Downlink Packet Access (“HSDPA”). UMTS also can be used to provide highly efficient, high-quality voice service.

19. EDGE was originally seen as the evolutionary path to 3G for TDMA networks, but EDGE was more closely related to GSM. Given the relatively low global penetration of TDMA compared to GSM and CDMA, vendors’ concentrated their development efforts on GSM 3G migration as compared to TDMA 3G migration, and TDMA development efforts, ultimately, faltered completely. Moreover, the substantial delay before EDGE services would be available meant that there would be a considerable time before TDMA-based networks would be able to offer data communications at the necessary increased speed levels. Given the expected demand for increasingly fast data services, the vendors’ inability to deliver TDMA-based 3G services was one of the factors that led them to discontinue efforts to develop TDMA-based 3G services and capabilities.

20. Meanwhile, the developers of the 2G CDMA standard, now known as cdmaOne, developed 3G technologies that were capable of being integrated into existing CDMA networks. This suite of technologies, known as cdma2000, included a 2.5G technology known as 1xRTT (single carrier radio transmission technology), that made it possible to offer medium-speed data

transmission before 3G services are deployed and offers a 12× capacity increase over analog. The principal 3G services in cdma2000 are 1xEV-DO (single carrier evolutionary, data-only) and 1xEV-DV (single carrier evolutionary, data and voice). 1xRTT and 1xEV-DO provide a CDMA carrier the ability to offer medium- and high- speed data, respectively, while 1xEV-DV can be used to provide both high-speed data and voice services. All of the CDMA-based technologies utilize paired 1.25 MHz channels and can be implemented within existing cdmaOne networks.

21. ***Cingular's and AWS's 3G Evolution Path.*** Faced with the technological obsolescence of TDMA and the need to be able to offer upgraded services to remain competitive, AWS and Cingular had little choice but to overlay a different technology over their TDMA networks as a path toward 3G. This required AWS and Cingular, unlike their CDMA competitors, to divide their spectrum among multiple technologies. As a result, constructing an overlay requires more spectrum than a single-technology network that can be migrated directly to 3G.

22. Cingular chose GSM as its overlay transition path to 3G service. GSM offered considerable advantages over the only other alternative, CDMA, because GSM is closest to a worldwide technology standard. The global deployment of GSM promised the advantage of worldwide roaming for GSM subscribers.<sup>2</sup> Also, GSM is widely supported by vendors and is the focus of vigorous 3G development efforts. As a result, GSM offered 3G deployment sooner and at a lower cost than CDMA. Also, the technical similarity of GSM to TDMA meant that dual-mode TDMA/GSM handsets could be developed more quickly than TDMA/CDMA handsets. Thus, Cingular found that GSM was the most realistic choice for its overlay. As discussed in the declaration of Greg Slemons of AWS ("Slemons Declaration"),<sup>3</sup> AWS reached similar conclusions.

23. In 2000, after TDMA had reached its limits in terms of 3G development, AWS announced that it had chosen GSM as the basis for its evolution to 3G services. As a result, AWS began deploying GSM and GPRS, and later EDGE, in its 1900 MHz networks. AWS's 850 MHz networks have remained largely TDMA-based, but AWS is in the process of deploying GSM/GPRS/EDGE technology at 850 MHz, as well as the already deployed system at 1900 MHz.

24. In 2001, Cingular announced that it had chosen GSM as the basis for its evolution to 3G services and that it would deploy GSM and GPRS in its 850 MHz networks as well as at 1900 MHz. Cingular was the first company in the world to use GSM at 850 MHz. In March 2002, vendors began making 850 MHz GSM infrastructure available, and by October 2002, handsets were available. Cingular integrated GPRS into all of its GSM networks from the start,

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<sup>2</sup> A number of different frequency bands are used around the world for GSM. Vendors have facilitated worldwide roaming in spite of the varying bands by offering multiband handsets. In addition, a customer who does not have a multiband handset may roam by switching his or her Subscriber Identity Module ("SIM card") from the handset used at home to a handset compatible with the host country's frequency plan. The SIM card is a GSM-standardized "smart card" containing the subscriber's number, dialing directory, and related information.

<sup>3</sup> The Declarants' references to the Slemons Declaration are based on review of a March 16, 2004 draft that is in substantially final form.

and all of its GSM overlay networks were designed to be EDGE-compatible. By summer of 2004, Cingular will have GSM technology deployed in all of its 850 MHz networks.

25. The GSM overlay employed by Cingular and AWS provides a path toward 3G at the cost of dividing limited spectrum up among different technologies, as discussed below. In most areas, the companies' need to support multiple technologies poses a potent obstacle to implementing 3G services on a broad scale. While each company would be able to introduce 3G services in a limited number of urban centers, they would be unable to do so on a national scale without acquiring more spectrum. This transaction will provide the merged company with the spectrum needed to bring broadband 3G services to consumers nationwide.

#### **IV. LIMITATIONS IMPOSED BY CURRENT CINGULAR SPECTRUM AVAILABILITY**

26. Cingular faces spectrum constraints that hamper its ability to provide the high quality its customers want in existing voice and data services in many metropolitan areas. These same spectrum constraints, aggravated by the need to support multiple legacy technologies, present major challenges with respect to responding to increased demand in the short term and introducing 3G services in the future. In many areas, Cingular will simply be unable to clear even a single 10 MHz block of spectrum needed to introduce UMTS without acquiring additional spectrum.

27. The most obvious constraint Cingular faces is that its spectrum holdings are limited. Even after Cingular completes its pending acquisition of spectrum from NextWave, Cingular will still hold 25 MHz or less of spectrum in a majority of the top 50 MSAs, including several where it will have no spectrum at all.

28. Cingular's spectrum shortage is aggravated by the need to support multiple technologies, which requires subdivision of its spectrum. In many of its 1900 MHz systems Cingular's spectrum is divided among TDMA and GSM, and in all of its 850 MHz systems Cingular has to divide its spectrum among analog, TDMA, and GSM. Cingular will complete the installation of GSM technology in all of its 850 MHz systems by this summer (currently 93% of pops covered), but must continue devoting spectrum on these systems to legacy analog and TDMA digital service for some time. The need to keep spectrum set aside for analog and TDMA limits the company's ability to take advantage of the efficiency of GSM technology — and even reduces the efficiency of the company's GSM service, which does not reach its maximum potential efficiency of 10× analog until 20 MHz of spectrum is devoted to GSM.

29. The amount of spectrum that is needed to support these legacy technologies is significant. In urban areas where Cingular provides 850 MHz service, a typical system currently uses about 4 MHz for analog service (two voice channels and one control channel per sector, which ensures that there is one voice channel available even if one fails) and about 11 MHz for providing TDMA service (including a guardband between TDMA and GSM). This leaves only about 10 MHz for Cingular's provision of GSM service, including GPRS/EDGE — and in order to offer GPRS/EDGE it is necessary to dedicate a minimum of two time slots to data service, making them unavailable to handle GSM voice traffic. The precise allocation of spectrum to the